

Is there a place for culture in life cycle sustainability assessment?

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Abstract

Purpose Cultures are increasingly recognised for their inherent value, yet, despite political and societal concern, culture is widely unrecognised in assessment techniques. Life cycle sustainability assessment (LCSA), a technique encompassing environmental, social and economic aspects, is growing in popularity. However, cultural values are rarely considered in LCSA. This paper reviews the meaning of culture; current efforts to include culture in environmental life cycle assessment (LCA), social LCA (S-LCA) and LCSA; and aspects to address when investigating integration of culture in LCA, S-LCA and LCSA.

Methods A literature review was undertaken on definitions of culture, recognition of culture in policy and decision making, and how culture is incorporated into assessment techniques. The potential for integrating culture in LCSA was evaluated in terms of the potential benefits and challenges.

Results Culture is often intangible and inaccessible, which may then lead to a lack of recognition in decision-making processes, or if it is recognised, then it is relegated as an afterthought. Explicitly including consideration of culture within LCSA will allow its representation alongside other sustainability aspects. The challenges of representing culture within LCSA include recognising when ‘culture’ should be distinguished from ‘social’; culture’s dynamic nature; the data

collection process; and the diversity of cultures between stakeholders and at different scales from community through to nation. The potential benefits of representing culture within LCSA include greater resonance of LCSA results with stakeholders; a more comprehensive decision support tool which appropriately accounts for values; and an assessment technique which may help protect communities and their diversity of cultures.

Conclusions Representing culture in LCSA is not straightforward and, to some extent, may be addressed through social indicators. However, developing LCSA to explicitly address cultural values has potential benefits. Future research should focus on opportunities for the development of (a) a culturally inclusive LCSA process and (b) additional cultural indicators and/or dimensions of existing LCSA indicators that represent cultural values.

Keywords Culture · Life cycle sustainability assessment · Quadruple bottom line

1 Introduction

Culture can traverse geography and time. It connects as well as separates people. It defines societies and distinguishes communities. Although evidence for the existence of culture is tangible, the concept itself is difficult to define and assess due in part to its often inaccessible and intangible nature. As a result, culture is rarely considered within many fields of research, whilst, arguably, it is an essential component. For example, in the area of ecosystem management, Chan et al. (2012b) argue that culture and cultural services provide “some of the most compelling reasons for conserving ecosystems” due to the inextricable links between ecosystems and peoples’ sense of identity, place, worldviews and well-being. This suggests that, in order to protect culture and the related

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diversity of worldviews, greater effort should be made to focus on recognising and accounting for culture and cultural values within both research and decision-making processes.

There are a few examples of cultural impact assessment tools (e.g. Palmer 2011; Stephenson 2008). In New Zealand, for instance, the Cultural Impact Assessment (CIA) tool has begun to emerge as a potential solution which can be used to provide culture-specific impact information. A CIA is “a report documenting Māori cultural values, interests and associations with an area or a resource, and the potential impacts of a proposed activity on these” (RMA Quality Planning Resource 2012). CIAs are increasingly utilised by local government councils during impact assessments related to tourism (Te Ao Marama Inc. 2004), urbanisation (Palmer 2011) and land use change (Coffin and Kawe 2011).

At the same time, there are relatively few examples (e.g. Harris and Harper 1997; Cochrane 2006) of existing sustainability assessment techniques being altered and reformed to address culture in addition to other dimensions of sustainability.

One sustainability technique is life cycle sustainability assessment (LCSA) which measures the environmental, social and economic impacts associated with product systems (Capitano et al. 2011; Ciroth et al. 2011; Finkbeiner et al. 2010; Guinée et al. 2011; Heijungs et al. 2010; Hu et al. 2013; Ketola and Salmi 2010; Klöpffer 2008; Moriizumi et al. 2010; Sala et al. 2013; Traverso et al. 2012; Valdivia et al. 2013; Vinyes et al. 2013; Wood and Hertwich 2012; Zamagni 2012; Zamagni et al. 2009; Zhou et al. 2007). According to Ciroth et al. (2011), LCSA is considered to be the future of environmental life cycle assessment (hereafter ‘LCA’) as it has greater potential to represent a variety of impacts beyond the conventional focus in LCA on environmental impacts. The combination of LCA with life cycle costing (LCC) and social LCA (S-LCA) to form LCSA has begun to gain momentum in the scientific world, with LCSA publications regarding, for example, marble products (Capitano et al. 2011), photovoltaic modules (Traverso et al. 2012), waste management of used cooking oil (Vinyes et al. 2013) and concrete recycling (Hu et al. 2013). Furthermore, The International Journal of Life Cycle Assessment recently published a special issue entitled, “Life Cycle Sustainability Assessment: From LCA to LCSA”, indicating that there is growing interest in the LCSA field. Cultural aspects are not readily evident within current LCSA methodology, but may be found in limited impact sub-categories (e.g. cultural heritage) in S-LCA; since there is no one group of recommended impact sub-categories, the representation of cultural impacts in the final LCSA results is not guaranteed. The underrepresentation of culture in LCSA may be unsurprising given that LCSA is still in its relative infancy.

This paper explores the varied meanings and uses of the term ‘culture’, its recognition in sustainability assessment

techniques (including LCA and S-LCA), and the potential challenges and benefits of representing culture within LCSA.

2 Culture

2.1 Definition of culture

There is a diverse range of cultures worldwide as well as a variety of interpretations and perspectives on the meaning of ‘culture’ (see Table 1). This range demonstrates the globally important role of culture and its ability to contribute to multiple areas of research.

Table 1 indicates how culture can be transdisciplinary as it is recognised in research fields from business to climate change, landscape management to sustainable development and indigenous knowledge to ecosystem valuation. Generally, culture is referred to as an emergent grouping of beliefs, knowledge, practices, values, ideas, language and worldviews within a social group; each of these elements affects the social group’s ongoing attitudes and behaviour. However, culture is not bound to a given geographical location or fixed in time. Indeed, culture is often thought of as an intergenerational concept. Nevertheless, culture’s broad range of definitions and uses also exposes its inherent complexity due to its distinctly dynamic nature. It is therefore perhaps not unexpected that there are challenges when attempting to represent culture within environmental management and planning (Satterfield et al. 2013).

For the purposes of the discussion in this paper, the general definition of ‘culture’ is used as defined by Anderson and Gale (1992, p. 3).

A dynamic mix of symbols, beliefs, languages and practices that people create, not a fixed thing or entity governing humans.

2.2 The recognition of culture

Culture is increasingly recognised, as evidenced by the number of national and international policy documents and agreements that are specifically concerned with culture, such as

- UNESCO (1972) (United Nations Educational, Scientific and Cultural Organisation) Resolution and Recommendation on the Studies and Development of Culture
- UNESCO (2001) Universal Declaration on Cultural Diversity
- UNESCO (2003) Convention for the Safeguarding of the Intangible Cultural Heritage
- United Nations (2007) Declaration on the Rights of Indigenous Peoples

Table 1 Definitions and uses for the term ‘culture’

| Source | Terminology | Definition | Type of research |
|---|-------------------------------------|---|---|
| Anderson and Gale (1992, p. 3) | Culture | “A dynamic mix of symbols, beliefs, languages and practices that people create, not a fixed thing or entity governing humans” (cited in Head et al. 2005) | Cultural geography |
| Llobera (2003, pp. 7–9) | Culture | “The totality of a people’s way of life, the whole complex of distinctive spiritual, material, intellectual and emotional features through which a society lives and reproduces itself” (cited in Kuruppu 2009) | Climate change adaptation |
| Hofstede (1980, p. 21) | Culture | “The collective programming of the mind which distinguishes the members of one human group from another.”; “includes systems of values, and values are among the building blocks of culture” | Work-related values |
| Lindsay (2005, p. 1) | Culture | “Culture influences attitudes and behaviour, varies within and across nations and within and across ethnicities, and is strongly embedded in Indigenous communities.” | Indigenous entrepreneurial attitudes |
| Cochrane (2006, p. 320) | Cultural capital | “Cultural capital, being the aptitude or inclination of a group or society to behave in a certain way, underlies human and social capital and describes the potential of a group or society”; “It includes elements such as socio-political institutions, values and needs, social preferences, environmental ethics and traditional ecological knowledge in a society.” | Sustainable development |
| Millennium Ecosystem Assessment (2005, p. 40) | Cultural ecosystem services | “Non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences” (cited in Schaich et al. 2010) | Cultural landscape research |
| King (2000, p. 7) | Cultural resource | “Any resource (i.e., thing that is useful for something) that is of a cultural character. Examples are social institutions, historic places, artefacts, and documents.” | Environmental impact assessment |
| Chan et al. (2012b, p. 9) | Cultural services | “Ecosystems’ contributions to the non-material benefits (e.g., capabilities and experiences) that arise from human–ecosystem relationships” | Ecosystem services |
| Billgren and Holmén (2008, p. 554) | Cultural theory | “Concerned with people’s values, ideas and worldviews” (cited in Thompson et al. 1990); people are strongly influenced by their social relations. | Natural resource management |
| Burger (2011, p. 137) | Eco-cultural attributes | “Cultural resources which derive from, and indeed require, intact and unspoiled natural ecosystems or settings for their cultural value” | Valuation of ecological resources |
| Groenfeldt (2003, pp. 919–920) | Indigenous cultural values | Indigenous: “minority cultural groups...that have a historic relationship to a particular territory and a marginalized relationship to the nation-state”; Cultural: “the system of values, beliefs, and ideas that social groups make use of in experiencing the world in mutually meaningful ways”; Values: “the guiding principles of a social group” | Cultural development |
| Howden (2001, pp. 60–62) | Indigenous knowledge | “A living system of information management which has its roots in ancient traditions. It relates to culture and artistic expression and to physical survival and environmental management. It controls individual behavior, as it does community conduct.”; “Indigenous knowledge systems are better understood as practical, personal and contextual units which cannot be detached from an individual, their community, or the environment (both physical and spiritual). (cited in Davis 2006) | Native land entitlements |
| UNESCO (2003, p. 2) | Intangible cultural heritage | “the practices, representations, expressions, knowledge, skills—as well as the instruments, objects, artefacts and cultural spaces associated therewith—that communities, groups and, in some cases, individuals recognize as part of their cultural heritage. This intangible cultural heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity.” | Cultural diversity and sustainable development |
| Stephenson and Moller (2009, p. 139) | Traditional Environmental Knowledge | “A cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and the environment” (cited in Berkes 2008) | Cross-cultural environmental research and management |
| Harris and Harper (1997, p. 793) | Tribal values | “Individual and collective well-being is derived from membership in a healthy community with access to ancestral lands and heritage resources, and from the ability to satisfy the personal responsibility to participate in traditional community activities and to help maintain the spiritual quality of a site, resource, or area.” | Subsistence exposure scenarios for tribal communities |

Environmental beliefs, ethics and values often differ between cultures (Cochrane 2006). Solutions to environmental issues, therefore, should not be universal but instead should take into account the unique cultural beliefs of a given area, ranging from local to national levels depending on the relevance of the issue. Indeed, one could argue that culture is integrally tied into the notion of environmental sustainability (UNESCO 2009) given that human beings (and the societies within which they exist) have a relationship with the natural environment that transcends biophysical definitions. The World Commission on Culture and Development (1995, p. 38) states:

It has become clear also that any approach that deals only with biophysical exchanges between societies and the environment is incomplete. The notion of sustainability raises the question of how nature itself is conceived and consequently of the cultural values that condition a society's relationship to nature. Important variants in attitudes to ecological sustainability demonstrate the need for a culturally diversified approach to issues of culture, environment and development, as well as for an analysis of mechanisms that perpetuate views or actions beneficial or harmful to the environment.

Many studies have highlighted the importance of recognising culture (albeit each with a varied definition of 'culture') within the planning and management of landscapes (Tengberg et al. 2012; Stephenson 2008), community development (Lane 2006), conservation initiatives (Daily et al. 2009), ecosystem management (Burger et al. 2008), local and national policy making (Berke et al. 2002), entrepreneurial attitude models (Lindsay 2005) and resource management (Ross and Pickering 2002).

Furthermore, culture is considered by some (e.g. Hawkes 2001; UNESCO 2001; Saastamoinen 2005; Nurse 2006) to be the fourth pillar of sustainability alongside economic, social and environmental considerations in what is often described as the 'quadruple bottom line'. There is a growing recognition of the quadruple bottom line within research topics such as sustainable societies (Ellyard 2008), community and environmental health (Luckman 2006), farming systems (Cooper 2011) and indigenous economic development (Scrimgeour and Iremonger 2004).

2.3 Assessment of culture

There is debate concerning how best to represent culture and the impacts on culture arising from different activities (Harris and Harper 1997). Some have argued that it is important to qualitatively assess and illustrate the extent of these impacts (e.g. MacLean 1996). Others believe that it is necessary to quantify the impacts so as to make them more readily

comparable with other quantitative impact categories (e.g. pollution, employment; National Research Council 1994).

Recent work to assess culture within, for example, the valuation of ecosystem services (e.g. Martín-López et al. 2009) has largely been focussed on translating culture into economic figures since doing so may allow the quantification of the relative value of different ecosystem functions. Such quantification of ecosystem functions may allow for the consideration and inclusion of associated non-market benefits (e.g. biodiversity or flood prevention) during resource management and development of related policy. Alternatively, Chan et al. (2012b) argue that to value cultures entirely in economic terms "cannot reflect the full extent of their differences from other ecosystem services" and risks the unintended interpretation that different cultures can be bought or sold. Although the authors do not have a solution to overcome this issue, they do stress that compartmentalising the value of culture into only economic terms is a simplification that hides culture's complex interconnectedness to other environmental, social or economic services.

There are a few examples of tools specifically designed to assess only cultural values. Examples include the use of an agent-based model to represent Māori cultural values (Montes de Oca Munguia et al. 2009), development of a cultural entrepreneurial attitude model (Lindsay 2005), mapping and quantifying cultural services (Plieninger et al. 2013) and the creation of a landscape-based cultural values model (Stephenson 2008).

However, Alonso and Medici (2012) emphasise that the lack of assessment tools that specifically include cultural aspects alongside environmental, economic and social aspects directly contributes to the marginalisation of culture, particularly regarding development policies. The authors argue that tools or methodologies are needed to adequately assess the effects on—and of—culture.

2.4 Culture and values

As referenced earlier in the definition by Hofstede (1980), "values are the building blocks of culture", and indeed, there are numerous references which highlight the relationship between values and culture. In their work on the effect of cultural values on economic development, Granato et al. (1996) noted that promoting the value of economic achievement in a given society affected that society's motivation, which in turn affected the rate of economic growth. Inglehart and Baker (2000) argue that understanding a society's beliefs, values and worldviews may enable one to predict the direction and rate of cultural change. In social psychological theory, both values and cultural norms play a large role in how people respond to and perceive fairness as well as how they manage uncertainty (van den Bos et al. 2005). Essentially, changes in values may cause a cultural shift in social attitudes and

behaviours in such areas as the equality of women, morality, desired traits for children to display and tolerance of foreigners (Schwartz 2006). Thus, values are inextricably linked with culture.

However, the notion of ‘value’ is arguably just as ambiguous as ‘culture’. It is used to refer to something of significance, worth or importance, and the value attached to this ‘something’ can vary between geographical location; scales (individual, community, regional, national); religions; political parties; and cultures. Frequently, value is ascribed to tangible, discrete objects. Indigenous values in particular are often associated with the presence of a traditional resource, sacred building or meaningful site (e.g. burial ground) which, when assessed or accounted for, is ultimately similar to the process of listing or categorising archaeological sites (Jackson 2006; English 2002; King 2000). Yet, values can also be attached to something that cannot be directly measured, such as a landscape or being able to perform a traditional activity.

Schwartz (1999, pp. 24–25) defines values as “conceptions of the desirable that guide the way social actors (e.g. organisational leaders, policy-makers, individual persons) select actions, evaluate people and events, and explain their actions and evaluations”; they are the “vocabulary of socially approved goals” which can be used to motivate, justify, communicate, inspire or condemn actions. In short, values are the “guiding principles in life”. Cultural values, Schwartz continues, can then be considered to represent specific societal norms, both implicitly and explicitly, and therefore focussing on such values directly is an efficient way of describing and representing cultures (Schwartz 2006).

Overall, then, there is some consensus that assessing cultures by using a value-based framework¹ is effective in deciphering and interpreting cultures (Leung et al. 2005; Javidan et al. 2006). But the “tightness of culture on the relationship of values and behaviour has yet to be explored systemically” (Roccas and Sagiv 2010, p. 35). It can be concluded that significant work still remains for the fair representation and assessment of intangible, holistic and aesthetic elements such as cultural values (Burger et al. 2008; Daily et al. 2009; Venn and Quiggin 2007).

3 Culture and values in LCA, S-LCA and LCSA

This section reviews how culture and values are currently present in LCA, S-LCA and LCSA. LCC is not discussed

¹ A value-based framework is an approach which assumes a distinct relationship between values and culture, and subsequently between culture and behaviour (Javidan et al. 2006). Scrimgeour and Iremonger (2004) argue that creating a value-based framework (including identifying culture-specific values, criteria, objectives and attributes) is useful for developing a values hierarchy which can then be used when deciding between alternatives.

here due to the limited number (though not totally absent, e.g. Gluch and Baumann 2004) of publications regarding the relevance of values and/or culture within the LCC process.

A review of the LCA literature suggests that there are two categories of approaches to inclusion of culture, and its constituent values, in LCA. One category of approaches focusses on recognising and allowing values to shape the process of undertaking an LCA study (Cowell 1998); generally, this takes the form of explicitly soliciting the values of stakeholders at the goal and scope definition phase of LCA and/or choosing impact assessment methods that are consistent with these values. The other category of approaches focusses on identifying and assessing additional impact categories (such as unique landscapes) and/or dimensions of environmental impacts (uncertainty of results, ability to manage impacts, etc.) whose degree of significance is generally recognised as being value-based. Examples are given in Section 3.1.

It may be argued that these two categories of approaches to include culture will also be applicable to S-LCA and LCSA. We return to this categorisation and its implications in Section 5.

3.1 Culture and values in LCA

The role of values in the process of undertaking LCA studies has been recognised in relation to defining the problem, goal and scope; the selection of impact category indicators; the optional weighting element at impact assessment; and interpretation of results (Hertwich and Hammitt 2001; Bare and Gloria 2008; Schmidt and Sullivan 2002; Bras-Klapwijk 1998; Tukker 2000; Hauschild 2005). Indeed, the ISO 14044 standard (ISO 2006) uses the term ‘value choices’ 15 times in conjunction with scope of the standard (Section 1); scope of the study (Section 4.2.3.1); classification and characterisation (Sections 4.4.2.2.2, 4.4.2.2.3, 4.4.2.4); weighting (Sections 4.4.3.1, 4.4.3.4.1, 4.4.3.4.2); ranking of impact categories (Section 4.4.3.3); comparative assertions (Section 4.4.5); interpretation (Section 4.5.2.3); and third-party reporting (Sections 5.2 and 5.3.2). Moreover, the values and worldviews of stakeholders can affect whether or not LCA is chosen as an analytical tool to support the decision-making process (Finnveden et al. 2003).

Regarding the problem, goal and scope definition, and choice to use LCA in a decision-making process, Ehrenfeld (1997) and Heiskanen (2000, 2002, 1999) highlight the role of life cycle thinking and/or LCA in “constructing problems in a distinctive way” (Heiskanen 2002, p. 434). And Coelho and McLaren (2013) show how the scope for three out of six LCA studies in different manufacturing companies changed during the process of undertaking the LCA studies—with a significant influence on the LCA results and associated implications for the decision situation. This suggests that the choices made

at goal and scope definition can be important when the LCA results are used to support decision making; arguably, values have an important—if largely unrecognised—role to play in influencing these choices about the inclusion of different processes on the basis that they are judged as more or less relevant to the decision situation.

The selection of impact category indicators obviously determines which types of environmental impacts are represented in LCA results. ISO 14044 is not specific about which impact category indicators are to be included in an LCA study, but requires that “the selection of impact categories, category indicators and characterization models shall be both justified and consistent with the goal and scope of the LCA. The selection of impact categories shall reflect a comprehensive set of environmental issues related to the product system being studied, taking the goal and scope into consideration” (ISO 2006, Section 4.4.2.2.1). Elghali et al. (2006) and Elghali et al. (2008) discuss how an LCA study was combined with decision conferencing to support a UK local authority decision about road maintenance; they highlight how additional environmental impact categories relevant to local people, but not normally included in LCA (such as noise and visual amenity), were identified through this process. However, they recognised that “a natural tension exists between the need to standardise information requirements for completeness in assessment and the needs of a particular local decision context, since in the former case the information required for the decision process may not be generated while in the latter there is a possibility that important data may be overlooked” (Elghali et al. 2006, p. 37). It is clear that choice of impact categories in an LCA study utilises value-based judgements about the relevance of different types of environmental impacts.

Weighting is recognised as being the element in an LCA study that “combines scientific results with value judgements” and “serves as a base for the interpretation of results” (Walz et al. 1996, p. 193). At weighting, values (including ethics, morals, worldviews and ideology) are recognised not only in the chosen weights but also in the chosen weighting method itself (Finnveden 1997). Bengtsson and Steen (2000, p. 102) describe the weighting process as a “value-laden expression of relative severity”. For example, a weighting method can be developed to account for the values of future generations (such as by using discounting techniques; Hellweg et al. 2003; Udo de Haes 2000), or those in a precautionary society may wish to apply a greater weight to LCA impact assessment results that have a high degree of uncertainty (Werner 2005; Tukker 2002a). Furthermore, Finnveden (1999, p. 35) notes that “if robust results are wanted, it can be important to use several methods and sets of weighting factors to examine the sensitivity of the results to different values and worldviews.” Miettinen and Hämäläinen (1997, p. 293) argue that there is no set of weights which can accurately reflect stakeholder

values in all situations since “they neither depend on the preferences of the actual decision makers nor on the attribute ranges that the product alternatives define”; weights and the weighting method should be chosen specifically for the LCA study at hand.

Interpretation of LCA results is explicitly recognised as requiring consideration of value choices made at goal and scope definition (ISO 2006, Section 4.5.2.3). However, the format in which LCA results are reported may also influence interpretation. A small number of studies have explicitly explored the use of different formats for the communication of LCA results (e.g. Dahlbo et al. 2013; Molina-Murillo and Smith 2009; Nissinen et al. 2007). Another group of studies have experimented with ‘actor LCA’, focussing on presenting the results of LCA studies in ways that represent the potential for different stakeholders (or ‘actors’) to realise potential improvement options at different stages along the product life cycle (e.g. Berlin et al. 2008; Brunklaus et al. 2010; Löfgren et al. 2011). The values of the LCA practitioner may influence the choice of presentation format and whether, for example, uncertainties and/or ranges of data are presented on impact assessment graphs and which processes are aggregated together (for example, whether transportation processes are subsumed within the other life cycle stages of a product system or separately represented on impact assessment graphs).

Turning to culture, its recognition in the LCA literature is quite limited. One example is that of Hofstetter et al. (2000) who, with the statement that all stages of an LCA should integrate subjective elements, suggest that a ‘valuesphere’ be added within LCA which would represent the views of the decision maker. The authors utilise cultural theory to apply three perspectives of social decision making: (a) hierarchy—“nature is tolerant”, (b) individualism—“nature is benign”, and (c) egalitarianism—“nature is fragile”. These three perspectives were also used in the LCA-based Ecoindicator’99 methodology (Goedkoop and Spriensma 1999) and are used in the ReCiPe method (Goedkoop et al. 2013). Accounting for differences in cultural perspectives will, in theory, help to “establish the seriousness” of environmental impacts (Baumann and Tillman 2004) and the “importance of damages” (Mettier and Hofstetter 2004), communicate and emphasise LCA results in a way which is most appropriate or effective for a given decision maker, and, overall, create a more robust decision support system. De Schryver et al. (2009) also applied cultural theory in their research on refining global warming characterisation factors and concluded that different cultural perspectives will significantly alter the relative importance of various impact indicators.

Another example of culture being recognised in LCA is seen in the work of Weidema and Lindeijer (2001). This research aimed to contribute to the development of ‘missing’ LCA elements that included ‘cultural values’. The authors interpret cultural values in a context of “unique landscapes

and unique archaeological sites”. It is this uniqueness, the authors argue, which inhibits cultural values from being a general indicator, and therefore they must be considered on a case-by-case basis. Nevertheless, the authors developed a general indicator to account for the disruption of “unknown archaeological sites” by relating the factors of disturbed soil depth, area and probability of site occurrence.

3.2 Culture and values in S-LCA

UNEP and SETAC (2009) define S-LCA as “a systematic process using best available science to collect best available data on and report about social impacts (positive and negative) in product life cycles from extraction to final disposal.” Social impacts occur when product or system changes create effects which in turn produce phenomena; these phenomena can be experienced by and influence people, thus leading to social impacts (Macombe et al. 2013; Vanclay 2002).

Though there are various examples of S-LCA methodologies, for the most part, they aim to mirror the LCA procedure comprising goal and scope definition, inventory analysis, impact assessment and interpretation (Benoît et al. 2010; Jørgensen et al. 2010, 2008; Hunkeler 2006; Arcese et al. 2013). Furthermore, although some aspects vary, an S-LCA generally follows the ISO 14044 framework (UNEP and SETAC 2009). Therefore, it can be postulated that the discussion in Section 3.1 related to LCA is also largely applicable to S-LCA.

The categories, sub-categories and inventory indicators proposed for S-LCA were developed primarily in relation to international initiatives, frameworks, and conventions promoting and protecting social well-being. Table 2 highlights the stakeholder categories and sub-categories developed for use within S-LCA which, to some extent, represent culture and cultural impacts (e.g. the sub-category of ‘cultural heritage’). Despite the representation of culture being evident, in particular, throughout the category of ‘Local Community’, Hutchins and Sutherland (2008) emphasise that many S-LCA studies tend to focus more on utilising the social indicators which are more aligned with those of LCA and environmental issues (e.g. human health) than on culturally related indicators.

In addition, culture is acknowledged as influencing “what is conceived as damaging or beneficial for the human dignity and well-being in a society” (Dreyer et al. 2006, p. 94). Thus, from the topics in Table 2, the extent to which child labour is accepted, corruption is resisted, or indigenous rights are respected within a society is largely affected by that society’s culture. For instance, in their evaluation of different S-LCA impact assessment methods, Parent et al. (2010) note that the use of a child labour indicator may raise uncertainties as to whether the child labour is a “cultural feature of the community” or “a company choice”. These cultural perceptions, unique to a given society, must be considered within S-LCA

Table 2 UNEP/SETAC (2009) list of recommended stakeholder categories and sub-categories to be reviewed within an S-LCA (Benoît et al. 2010)

| Stakeholder categories | Sub-categories |
|--|---|
| Worker | Freedom of association and collective bargaining Child labour Fair salary Working hours Forced labour Equal opportunities/discrimination Health and safety Social benefits/social security |
| Consumer | Health and safety Feedback mechanism Consumer privacy Transparency End of life responsibility |
| Local community | Access to material resources Access to immaterial resources Delocalisation and migration Cultural heritage Safe and healthy living conditions Respect of indigenous rights Community engagement Local employment Secure living conditions |
| Society | Public commitments to sustainability issues Contribution to economic development Prevention and mitigation of armed conflicts Technology development Corruption |
| Value chain actors (not including consumers) | Fair competition Promoting social responsibility Supplier relationships Respect of intellectual property rights |

in order for the subsequent results to be relevant and meaningful to the society involved (Hauschild et al. 2008; Dreyer et al. 2006).

3.3 Culture and values in LCSA

As mentioned in Section 2.2, recognition of culture as a fourth pillar of sustainability (alongside economic, social and environmental aspects) is gaining momentum and is often referred to as the ‘quadruple bottom line’. New Zealand, in particular, has been one of the first countries in the world to adopt and

promote the application of a quadruple bottom line throughout governmental activities. Until the 1970s, indigenous Māori were largely excluded from government planning (Dalziel et al. 2006). In 1991, the Resource Management Act was created which references the Treaty of Waitangi (the original signed agreement between Māori and the British settlers) and thus strongly advocates the recognition and respect of Māori culture in resource management decision making. Legislation introduced in 2003 required “councils to plan and work on the basis of the ‘quadruple bottom line’ approach and undertake quadruple bottom line reporting—considering social, economic, environmental and cultural impacts” (Spiller and Lake 2003, p. 15). Dalziel et al. (2006), discussing local government legislation, state that each of the four components of sustainability is strongly linked and mutually dependent; it is essential not to neglect a particular component, nor to consider any of them in isolation. And Montes de Oca Munguia et al. (2009), in the context of representing Māori cultural values in land use management, argue that a methodology which is readily able to illustrate economic, social, environmental and cultural data related to land use (current or proposed) is lacking.

However, the inclusion or recognition of culture (and/or changes in culture) within LCSAs is virtually non-existent, apart from rare exceptions such as Ketola and Salmi (2010). The authors conducted a holistic LCSA, including culture, which compared different biofuels. They performed semi-structured interviews with a variety of decision makers in order to identify their perspectives regarding environmental, social, cultural and economic impacts associated with different types of biofuels. The cultural results related to, for instance, biodiesels indicate that many stakeholders felt there would be a loss of cultural landscapes during the growing stage of the crop used to produce biodiesel. The results from the interviews were represented qualitatively rather than quantitatively, i.e. they did not present discrete cultural indicators but instead discussed cultural aspects identified during the interviews.

3.4 Benefits of recognising culture in LCA, S-LCA and LCSA

People are often intimately connected with their culture, and this connection can influence one’s way of life, sense of identity (individually and as part of a larger group) and level of engagement in social processes (Stephenson 2008; Thrift and Whatmore 2004). To this effect, Article 13 of UNESCO’s Convention on the Protection and Promotion of the Diversity of Cultural Expressions states that “parties shall endeavour to integrate culture in their development policies at all levels for the creation of conditions conducive to sustainable development” (UNESCO 2005, p. 8). This process of integrating culture into policy can be beneficial as sustainable

development which recognises culture is more likely to be successful, especially regarding the public’s acceptance of proposed development initiatives (Macnaghten and Jacobs 1997). Indeed, developmental change that is *not* embedded in the values and knowledge of a community may be like “trying to walk through a locked door after throwing away the key” (Gould 2001, p. 69).

Indigenous or traditional cultural values especially are in danger of being diluted or disappearing altogether. If modern societies wish to protect these cultural values, Groenfeldt (2003) argues that the global community must support local indigenous participation in resource management and development planning; embrace indigenous spiritual practices and worldviews within environmental conservation; recognise and protect indigenous rights to land and water resources; and respect indigenous identity as it is the cornerstone of cultural values.

The representation of culture in LCA (through, for example, recognising and allowing values to shape the process of undertaking an LCA study and/or through identification of additional indicators) may provide an appropriate platform with which to address Groenfeldt’s recommendations. Since values are at the heart of multi-objective decisions, accounting for values in LCA may lead to it becoming a more robust decision support tool (Hofstetter et al. 2000). Structuring an LCA study to be consistent with the values of the intended audience will ensure that the LCA results are in an appropriate context (Bengtsson and Steen 2000). Werner and Scholz (2002) and Heiskanen (2000) assert that LCAs guided by the values and worldviews of the decision maker(s) can result in clear-cut and focussed decision situations. On the other hand, failure to transparently reflect values during the LCA process, particularly if its application is to aid policy making, may lead to a collapse in meaningful communication, discussion and even acceptance of the results (Bras-Klapwijk 1998; Finnveden 1997).

The technique of S-LCA has made efforts to represent culture within its methodology as there are sub-categories which may be addressed with a cultural focus (Benoît et al. 2010). Many sub-categories (cultural or otherwise), however, are not necessarily mandatory to complete an S-LCA; it depends on the goal and scope of the study at hand as well as the context of the study’s geographical and cultural settings (Hauschild et al. 2008; Zamagni et al. 2011). Therefore, an S-LCA may not always be considered to have accounted for culture in its process and/or results.

Whilst cultural considerations in LCSA have rarely been incorporated, the potential exists to do so. Indeed, Jeswani et al. (2010, p. 124) state that “broadening LCA towards social, cultural and economic aspects would move LCA from environmental towards sustainability assessments”, thereby creating “an opportunity to increase the significance of LCA in political spheres beyond environmental policy”.

Furthermore, Allenby et al. (2007) argue that the whole of industrial ecology, the discipline in which LCSA sits, should encourage continued expansion of LCSA to include cultural considerations as it represents an “important opportunity”.

4 Issues when thinking about integrating culture into LCSA

4.1 Social versus cultural indicators

But why distinguish between the social and cultural dimensions within sustainability? It is true that social and cultural aspects are not entirely separate; social and cultural traits do not evolve independently from one another (Weinstein 2005). However, there are differences between social and cultural aspects. In anthropology, for example, Barrett (2009) notes that the term ‘cultural’ embraces beliefs and values whilst the term ‘social’ refers to social structures (e.g. institutions, roles, etc.).

Social and cultural indicators also demonstrate distinct differences. Table 3 illustrates how the labelling of ‘social’ or ‘cultural’ indicators differs amongst various policies, guidelines or other research documents. Some indicators, such as ‘language’, tend to be considered cultural, whilst others, such as ‘health’, are thought of in a social context. Although there is some overlap (e.g. the ‘education’ indicator), one may argue that there is still enough difference between social and cultural indicators to justify representing them separately within an assessment methodology such as LCSA. However, it is worth stressing the importance of focussing efforts across all relevant fields of study to achieve more consensus and consistency between the use of social and cultural indicators. Only when this is done can the meaningful progression of these indicators be realised.

4.2 The dynamic nature of culture

It is important to note that cultural values and knowledge are neither static (Jacobs and Mulvihill 1995; UNESCO 2009) nor homogenous; there is no single perspective, interpretation, definition or value system that can summarise an entire culture indefinitely (Hardy and Patterson 2012). Just as economies and ecological habitats change over time, so may certain cultural values, thus implying the need for their periodic assessment and reconsideration within decision-making processes. In order to cope with dynamic cultural elements, efforts should be focussed on developing frameworks to represent culture that can adapt to their subtle nuances, reflecting how these change in different contexts. Perhaps successful frameworks could be created by conceptualising culture in more detail (e.g. from socioeconomic–political drivers of change; Leung et al. 2005). In the context of international

business development, Leung et al. suggest systematically characterising the complexity of cultures in a way which allows for the identification of when and how the effects of cultural considerations may impact the decision-making process. These effects can then be integrated into business models and theories.

4.3 Data challenges

Inclusion of specific cultural indicators in S-LCA and LCSA studies, in particular, requires extensive data collection and analysis across a range of aspects. Some aspects may be numerical (such as with economic data) and other aspects may be more narrative (as is often the case with cultural data). LCSA research, therefore, may require a mixture of both quantitative and qualitative methods (i.e. mixed-methods research). Teddlie and Tashakkori (2008, pp. 5–6) define quantitative methods as “the techniques associated with the gathering, analysis, interpretation, and presentation of *numerical* information” and qualitative methods as “the techniques associated with the gathering, analysis, interpretation, and presentation of *narrative* information”.

The data collection process is often the area with the most limitations. These limitations may be due to data being restricted, uncertain, unavailable, inaccurate, unreliable, etc. Collecting generally less discrete and tangible cultural data may also prove difficult. Some researchers (e.g. Chan et al. 2012b; Keeney and Gregory 2005; Tipa and Teirney 2003) have handled this challenge by creating a community-constructed metric or scale (e.g. 1–5) which translates qualitative data into numerical scores. Also, Chan et al. (2012a) developed an engagement framework which can be used to integrate culture into ecosystem services research and decision making. Furthermore, some researchers have advocated a requirement for site-specific data and others have asserted that general, published statistics are adequate (Jørgensen et al. 2008). Ultimately, the decision between site-specific and more general data is highly dependent on how much time and resources are available for the data collection phase since collection of site-specific data will undoubtedly require a significant amount more effort.

A key challenge is the collection and representation of any qualitative (social or cultural) information which may not be suitable to represent in the format of a functional unit (Klöpffer 2008; Arcese et al. 2013). If this is the case, then proportional weighting may be used to transform the qualitative results into a format which allows them to be summarised per functional unit (Benoît et al. 2010).

Yet, Espeland (2001) cautions that, when recognising culture, it is important to not only account for what people value (e.g. land) and how much they value it (e.g. on a scale of 1–10) but also to understand the process of *how* they value; when we convert their values into new, often numerical, configurations,

Table 3 Labelling of indicator-s

| KEY | Health | Political participation | Safety | Housing | Skills | Social connectedness | Employment | Recreation & tourism | Education | Language | Autonomy | Media communication | Artistic creation | Protection of culture & places |
|---|--------|-------------------------|--------|---------|--------|----------------------|------------|----------------------|-----------|----------|----------|---------------------|-------------------|--------------------------------|
| | | | | | | | | | | | | | | |
| Arctic social indicators (Nordic Council of Ministers 2010) | | | | | | | | | | | | | | |
| Investing in cultural diversity (UNESCO 2009) | | | | | | | | | | | | | | |
| New Zealand Sustainable Development (Department of Prime Minister and Cabinet 2003) | | | | | | | | | | | | | | |
| Cultural Indicators: Views from Africa Task Force (UNESCO 2010) | | | | | | | | | | | | | | |
| Sustainable Management of Temperate & Boreal Forests (The Montréal Process 2009) | | | | | | | | | | | | | | |
| Indicators for Aboriginal forestry (Saint-Arnaud et al. 2009) | | | | | | | | | | | | | | |
| Māori sustainable economic development (Scrimgeour and Iremonger 2004) | | | | | | | | | | | | | | |
| European System of Social Indicators (Noll 2002) | | | | | | | | | | | | | | |
| Social indicators (OECD 2011) | | | | | | | | | | | | | | |
| Sustainability indicators for community tourism (Choi and Sirakaya 2006) | | | | | | | | | | | | | | |
| Sustainable development indicators for mining (Azapagic 2004) | | | | | | | | | | | | | | |
| ISO 26000 Social responsibility (ISO 2010) | | | | | | | | | | | | | | |
| Guidelines on S-LCA of products (UNEP and SETAC 2009) | | | | | | | | | | | | | | |

Labelling of indicators as either ‘social’ or ‘cultural’ is not always consistent, as demonstrated by various policies, guidelines and other research studies (in the left column). Yet, it is evident that the indicators are not homogenous; thus, a distinction between ‘social’ and ‘cultural’ is needed.

we may inadvertently be “threatening their integrity as social beings”.

4.4 Diversity of cultures between stakeholders and scales

The ‘value’ of culture can be diversely defined depending both on stakeholders (i.e. their specific cultural background) and on scale (e.g. a sacred site may have more cultural significance to a stakeholder at a local scale than at a global one; Hein et al. 2006; Head et al. 2005). Decision making in general is a complex process primarily due to the typically large number of stakeholder aspirations, goals and objectives which must be considered in order to make a balanced decision (Finkbeiner et al. 2010). Hein et al. (2006), for example, examined how stakeholders valued ecosystem services of the De Wieden wetland in the Netherlands at various scales. The results indicated that local stakeholders are more likely to value the enhanced fishing benefits whilst national stakeholders will more highly value the potential for increased biodiversity. However, the authors acknowledge that it is challenging to understand how intricate spatial associations within landscapes and ecosystems affect and are affected by a particular action such as flood prevention measures.

One possible way to account for this diversity of cultures is to engage with stakeholders (including members of relevant communities); thus, participatory techniques may be used in order to, for example, enhance the underlying LCSA framework and/or indicators. Extensive stakeholder participation is uncommon in the process of undertaking LCA and LCSA studies. Yet, an LCA undertaken using participatory techniques may lead to more balanced and socially accepted results (Tukker 2002b). An LCSA process, especially one that is inclusive of both social and cultural aspects, has the potential to have much more stakeholder involvement during, for example, the data collection or inventory phase. Indeed, in their review of cultural ecosystem service indicators, Hernández-Morcillo et al. (2013) note that utilising participatory mapping tools can greatly increase the quality and visibility of intangible cultural attributes, thereby allowing for more informed decision making in regional landscape planning. Valdivia et al. (2013) suggest that future LCSA studies should create subsequent guidance of how stakeholder engagement was utilised (perhaps even iteratively) throughout the process of undertaking the study.

5 Discussion on how to represent culture in LCSA

In recent years, there has been increased recognition of the need for a more holistic and comprehensive extension of the environmentally focussed LCA methodology. Indeed, Heiskanen (2001) argues that “the exclusion of non-quantifiable and non-environmental issues from LCA” does

not generally correspond with how ordinary people (i.e. non-LCA professionals) see the life cycle method. Instead, she recommends anchoring LCA in the culture and worldviews of decision makers, both on personal and organisational levels, arguing that doing so may facilitate the interpretation, endorsement and uptake of LCA (Heiskanen 2000).

The inclusion of non-environmental issues in LCA has been pursued, as noted in Section 3, through two categories of approaches: (a) focussing on recognising and allowing values to shape the process of undertaking a study and/or (b) identifying additional impact categories and/or dimensions of environmental impacts that can be represented at the impact assessment and interpretation phases of a study. The more recent emphasis upon the development of S-LCA and LCSA provides an opportunity to recognise culture and/or cultural values in these sustainability assessment techniques alongside LCA. Other studies suggest that this may be possible. Concerning the first category of approaches (allowing values to shape the process of undertaking a study), an example is Stevenson (1996) who developed an approach for including the indigenous knowledge and values of a First Nation tribe in Canada in Environmental Impact Assessment (EIA). Stevenson argues that it is beneficial to recognise and incorporate indigenous knowledge and values into all stages of an EIA, thereby enhancing the potential for EIAs to become more holistic. Concerning the second category of approaches (development of additional impact categories), an example is Axelsson et al. (2013) who attempted to map cultural sustainability in the context of land use planning in Sweden. Their cultural indicators included ‘cultural landscape’ (in number of active farmers per square kilometre) and ‘cultural heritage’ (in number of historical remains per square kilometre).

Thus, future research should focus on opportunities for the development of (a) a culturally inclusive LCSA process and (b) additional cultural indicators and/or dimensions of existing LCSA indicators that represent cultural values. Attention should also be given to whether the inclusion of culture in LCSA is more appropriate for some decision situations than others, e.g. public policy making, decisions involving alternative uses of land. The challenges to be explored in representing culture within LCSA include recognising when ‘culture’ should be distinguished from ‘social’; culture’s dynamic nature; the data collection process; and the diversity of cultures between stakeholders and at different scales from community through to nation.

In conclusion, as different cultures are valued for their inherent importance and distinct worldviews, and as culture is often overlooked in existing sustainability assessment techniques, there is an opportunity for this aspect to be integrated into the emerging LCSA technique. Presenting decision makers with information about economic, social, environmental and cultural aspects will allow them to simultaneously consider a range of impacts associated with a given process

or product, not just impacts associated with one or two aspects. The potential benefits of representing culture within LCSA include a more comprehensive decision support tool which appropriately accounts for values, greater resonance of LCSA results with stakeholders and an assessment technique which may help protect the rich diversity of cultures found in communities across the world.

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References

- Allenby B, Allen D, Davidson C (2007) Sustainable engineering: from myth to mechanism. *Environ Qual Manag* 17(1):17–26
- Alonso G, Medici M (2012) UNESCO culture for development indicators suite: a tool to incorporate culture into development strategies. In: van Hooff H, Brugman F, Betancourt G, Martin E, Guzmán B (eds) *Culture and development*, vol 7. UNESCO, Paris, pp 12–17
- Anderson K, Gale F (1992) Introduction. In: Anderson K, Gale F (eds) *Inventing places: studies in cultural geography*. Longman Cheshire, Melbourne, pp 1–14
- Arcese G, Lucchetti MC, Merli R (2013) Social life cycle assessment as a management tool: methodology for application in tourism. *Sustain* 5:3275–3287
- Axelsson R, Angelstam P, Degerman E, Teitelbaum S, Andersson K, Elbakidze M, Drotz MK (2013) Social and cultural sustainability: criteria, indicators, verifier variables for measurement and maps for visualization to support planning. *Ambio* 42(2):215–228
- Azapagic A (2004) Developing a framework for sustainable development indicators for the mining and minerals industry. *J Clean Prod* 12(6): 639–662
- Bare JC, Gloria TP (2008) Environmental impact assessment taxonomy providing comprehensive coverage of midpoints, endpoints, damages, and areas of protection. *J Clean Prod* 16(10):1021–1035
- Barrett SR (2009) *Anthropology: a student's guide to theory and method*. University of Toronto Press Incorporated, Toronto
- Baumann H, Tillman AM (2004) *The hitch hiker's guide to LCA: an orientation in the life cycle assessment methodology and application*. Studentlitteratur, Sweden
- Bengtsson M, Steen B (2000) Weighting in LCA—approaches and applications. *Environ Prog* 19(2):101–109
- Benoît C, Norris GA, Valdivia S, Ciroth A, Moberg A, Bos U, Prakash S, Ugaya C, Beck T (2010) The guidelines for social life cycle assessment of products: just in time! *Int J Life Cycle Assess* 15(2):156–163
- Berke PR, Ericksen N, Crawford J, Dixon J (2002) Planning and Indigenous people human rights and environmental protection in New Zealand. *J Plan Educ Res* 22(2):115–134
- Berkes F (2008) *Sacred ecology*. Routledge, New York
- Berlin J, Sonesson U, Tillman AM (2008) Product chain actors' potential for greening the product life cycle. *J Ind Ecol* 12(1):95–110
- Billgren C, Holmén H (2008) Approaching reality: comparing stakeholder analysis and cultural theory in the context of natural resource management. *Land Use Policy* 25(4):550–562
- Bras-Klapwijk RM (1998) Are life cycle assessments a threat to sound public policy making? *Int J Life Cycle Assess* 3(6):333–342
- Brunklaus B, Thormark C, Baumann H (2010) Illustrating limitations of energy studies of buildings with LCA and actor analysis. *Build Res Inf* 38(3):265–279
- Burger J (2011) Valuation of environmental quality and eco-cultural attributes in northwestern Idaho: Native Americans are more concerned than Caucasians. *Environ Res* 111(1):136–142
- Burger J, Gochfeld M, Pletnikoff K, Snigaroff R, Snigaroff D, Stamm T (2008) Ecocultural attributes: evaluating ecological degradation in terms of ecological goods and services versus subsistence and tribal values. *Risk Anal* 28(5):1261–1272
- Capitani C, Traverso M, Rizzo G, Finkbeiner M (2011) Life cycle sustainability assessment: an implementation to marble products. LCM 2011 Conference, Berlin, 29–31 August 2011
- Chan K, Guerry AD, Balvanera P, Klain S, Satterfield T, Basurto X, Bostrom A, Chuenpagdee R, Gould R, Halpern BS (2012a) Where are cultural and social in ecosystem services? A framework for constructive engagement. *Biogeosciences* 62(8):744–756
- Chan K, Satterfield T, Goldstein J (2012b) Rethinking ecosystem services to better address and navigate cultural values. *Ecol Econ* 74:8–18
- Choi HC, Sirakaya E (2006) Sustainability indicators for managing community tourism. *Tour Manag* 27(6):1274–1289
- Ciroth A, Finkbeiner M, Hildenbrand J, Klöpffer W, Mazijn B, Prakash S, Sonnermann G, Traverso M, Ugaya C, Valdivia S, Vickery-Niederman G (2011) Towards a life cycle sustainability assessment: making informed choices on products. UNEP/SETAC Life Cycle Initiative, Nairobi
- Cochrane P (2006) Exploring cultural capital and its importance in sustainable development. *Ecol Econ* 57(2):318–330
- Coelho CRV, McLaren SJ (2013) Rethinking a product and its function using LCA—experiences of New Zealand manufacturing companies. *Int J Life Cycle Assess* 18:872–880
- Coffin AN, Kawe TP (2011) Matakana island planning: an assessment of cultural values and identification of potential effects of urbanisation and land-use change on Maori communities of Makatana and Rangiwaea islands. Tauwhao Te Ngare Trust
- Cooper I (2011) Economic and social influences on the nature, functioning and sustainability of rainfed farming systems. In: Tow PG (ed) *Rainfed farming systems*. Springer, London, pp 299–320
- Cowell SJ (1998) *Environmental life cycle assessment of agricultural systems: integration into decision-making*. University of Surrey, Guildford
- Dahlbo H, Koskela S, Pihkola H, Nors M, Federley M, Seppälä J (2013) Comparison of different normalised LCIA results and their feasibility in communication. *Int J Life Cycle Assess* 18:850–860
- Daily GC, Polasky S, Goldstein J, Kareiva PM, Mooney HA, Pejchar L, Ricketts TH, Salzman J, Shallenberger R (2009) Ecosystem services in decision making: time to deliver. *Front Ecol Environ* 7(1):21–28
- Dalziel P, Matunga H, Saunders C (2006) Cultural well-being and local government: lessons from New Zealand. *Australas J Reg Stud* 12(3):267–280
- Davis M (2006) Bridging the gap or crossing a bridge? Indigenous knowledge and the language of law and policy. In: Reid WV, Berkes F, Wilbanks TJ, Capistrano D (eds) *Bridging scales and knowledge systems: concepts and applications in ecosystem assessment*. Island Press, Washington, pp 145–163
- De Schryver AM, Brakkee KW, Goedkoop MJ, Huijbregts MAJ (2009) Characterization factors for global warming in life cycle assessment based on damages to humans and ecosystems. *Environ Sci Technol* 43(6):1689–1695
- Department of Prime Minister and Cabinet (2003) *Sustainable development for New Zealand: programme of action*. Wellington, New Zealand
- Dreyer L, Hauschild M, Schierbeck J (2006) A framework for social life cycle impact assessment. *Int J Life Cycle Assess* 11(2):88–97
- Ehrenfeld JR (1997) The importance of LCAs—warts and all. *J Ind Ecol* 1(2):41–49

- Elghali L, Cowell SJ, Begg KG, Clift R (2006) Support for sustainable development policy decisions: a case study from highway maintenance. *Int J Life Cycle Assess* 11(1):29–39
- Elghali L, Clift R, Begg KG, McLaren S (2008) Decision support methodology for complex contexts. *Eng Sustain* 161:7–22
- Ellyard P (2008) Designing and innovating a sustainable society. In: Newton P (ed) *Transitions: pathways towards sustainable urban development in Australia*. CSIRO, Collingwood, pp 675–682
- English A (2002) More than archaeology: developing comprehensive approaches to Aboriginal heritage management in NSW. *Aust J Environ Manag* 9(4):218–227
- Espeland WN (2001) Value-matters. *Econ Polit Wkly* 36(21):1839–1845
- Finkbeiner M, Schau EM, Lehmann A, Traverso M (2010) Towards life cycle sustainability assessment. *Sustain* 2(10):3309–3322
- Finnveden G (1997) Valuation methods within LCA—where are the values? *Int J Life Cycle Assess* 2(3):163–169
- Finnveden G (1999) A critical review of operational valuation/weighting methods for life cycle assessment. Stockholm, Sweden
- Finnveden G, Nilsson M, Johansson J, Persson Å, Moberg Å, Carlsson T (2003) Strategic environmental assessment methodologies—applications within the energy sector. *Environ Impact Assess Rev* 23:91–123
- Gluch P, Baumann H (2004) The life cycle costing (LCC) approach: a conceptual discussion of its usefulness for environmental decision-making. *Build Environ* 39(5):571–580
- Goedkoop M, Spriensma R (1999) The Eco-indicator'99: a damage oriented method for life cycle impact assessment: methodology report. Amersfoort, the Netherlands
- Goedkoop M, Heijungs R, Huijbregts M, De Schryver A, Struijs J, van Zelm R (2013) ReCiPe 2008: a life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level. <http://www.lcia-recipe.net/>. Accessed 9 October 2013
- Gould H (2001) Culture and social capital. In: Matarosso F (ed) *Recognising culture: a series of briefing papers on culture and development*. Comedia, the Department of Canadian Heritage and UNESCO, London, pp 69–75
- Granato J, Inglehart R, Leblang D (1996) The effect of cultural values on economic development: theory, hypotheses, and some empirical tests. *Am J Polit Sci* 40(3):607–631
- Groenfeldt D (2003) The future of indigenous values: cultural relativism in the face of economic development. *Futures* 35(9):917–929
- Guinée JB, Heijungs R, Huppes G, Zamagni A, Masoni P, Buonamici R, Ekvall T, Rydberg T (2011) Life cycle assessment: past, present, and future. *Environ Sci Technol* 45(1):90–96
- Hardy DJ, Patterson MG (2012) Cross-cultural environmental research in New Zealand: insights for ecological economics research practice. *Ecol Econ* 73:75–85
- Harris SG, Harper BL (1997) A Native American exposure scenario. *Risk Anal* 17(6):789–795
- Hauschild MZ (2005) Assessing environmental impacts in a life-cycle perspective. *Environ Sci Technol* 39(4):81A–88A
- Hauschild MZ, Dreyer L, Jørgensen A (2008) Assessing social impacts in a life cycle perspective—lessons learned. *CIRP Ann-Manuf Tech* 57(1):21–24
- Hawkes J (2001) The fourth pillar of sustainability: culture's essential role in public planning. Common Ground Publishing, Victoria, Australia
- Head L, Trigger D, Mulcock J (2005) Culture as concept and influence in environmental research and management. *Conserv Soc* 3(2):251
- Heijungs R, Huppes G, Guinée JB (2010) Life cycle assessment and sustainability analysis of products, materials and technologies: toward a scientific framework for sustainability life cycle analysis. *Polym Degradation Stab* 95(3):422–428
- Hein L, Van Koppen K, De Groot RS, Van Ierland EC (2006) Spatial scales, stakeholders and the valuation of ecosystem services. *Ecol Econ* 57(2):209–228
- Heiskanen E (1999) Every product casts a shadow: but can we see it, and can we act on it? *Env Sci Pol* 2:61–74
- Heiskanen E (2000) Managers' interpretations of LCA: enlightenment and responsibility or confusion and denial? *Bus Strat Env* 9(4):239–254
- Heiskanen E (2001) Institutionalization of life-cycle thinking in the everyday discourse of market actors. *J Ind Ecol* 4(4):31–45
- Heiskanen E (2002) The institutional logic of life cycle thinking. *J Clean Prod* 10:427–437
- Hellweg S, Hofstetter T, Hungerbühler K (2003) Discounting and the environment: should current impacts be weighted differently than impacts harming future generations? *Int J Life Cycle Assess* 8(1):8–18
- Hernández-Morcillo M, Plieninger T, Bieling C (2013) An empirical review of cultural ecosystem service indicators. *Ecol Indic* 29:434–444
- Hertwich EG, Hammitt JK (2001) A decision-analytic framework for impact assessment. Part I: LCA and decision analysis. *Int J Life Cycle Assess* 6(1):5–12
- Hofstede G (1980) *Culture's consequences: international differences in work-related values*, vol 5. Sage, London
- Hofstetter P, Baumgartner T, Scholz RW (2000) Modelling the valuesphere and the ecosphere: integrating the decision makers' perspectives into LCA. *Int J Life Cycle Assess* 5(3):161–175
- Howden K (2001) Indigenous traditional knowledge and native title. *Univ New South Wales Law J* 24(1):60–84
- Hu M, Kleijn R, Bozhilova-Kisheva KP, Di Maio F (2013) An approach to LCSA: the case of concrete recycling. *Int J Life Cycle Assess* 18(9):1793–1803
- Hunkeler DJ (2006) Societal LCA methodology and case study. *Int J Life Cycle Assess* 11(6):371–382
- Hutchins MJ, Sutherland JW (2008) An exploration of measures of social sustainability and their application to supply chain decisions. *J Clean Prod* 16(15):1688–1698
- Inglehart R, Baker WE (2000) Modernization, cultural change, and the persistence of traditional values. *Am Soc Rev* 65(1):19–51
- ISO (2006) ISO 14044 international standard. Environmental management—life cycle assessment—requirements and guidelines. International Organisation for Standardization, Geneva, Switzerland
- ISO (2010) ISO 26000: social responsibility. International Organisation for Standardization, Geneva, Switzerland
- Jackson S (2006) Compartmentalising culture: the articulation and consideration of Indigenous values in water resource management. *Aust Geogr* 37(1):19–31
- Jacobs P, Mulvihill P (1995) Ancient lands: new perspectives. Towards multi-cultural literacy in landscape management. *Landsc Urban Plann* 32(1):7–17
- Javidan M, House RJ, Dorfman PW, Hanges PJ, De Luque MS (2006) Conceptualizing and measuring cultures and their consequences: a comparative review of GLOBE's and Hofstede's approaches. *J Int Bus Stud* 37(6):897–914
- Jeswani HK, Azapagic A, Schepelmann P, Ritthoff M (2010) Options for broadening and deepening the LCA approaches. *J Clean Prod* 18(2):120–127
- Jørgensen A, Le Bocq A, Nazarkina L, Hauschild M (2008) Methodologies for social life cycle assessment. *Int J Life Cycle Assess* 13(2):96–103
- Jørgensen A, Finkbeiner M, Jørgensen MS, Hauschild MZ (2010) Defining the baseline in social life cycle assessment. *Int J of Life Cycle Assess* 15(4):376–384
- Keeney RL, Gregory RS (2005) Selecting attributes to measure the achievement of objectives. *Op Res* 53(1):1–11
- Ketola T, Salmi T (2010) Sustainability life cycle comparison of biofuels: sewage the saviour? *Manag Env Qual: An Int J* 21(6):796–811
- King TF (2000) What should be the “cultural resources” element of an EIA? *Environ Impact Assess Rev* 20(1):5–30

- Klöpffer W (2008) Life cycle sustainability assessment of products. *Int J Life Cycle Assess* 13(2):89–95
- Kuruppu N (2009) Adapting water resources to climate change in Kiribati: the importance of cultural values and meanings. *Env Sci Pol* 12(7):799–809
- Lane MB (2006) The role of planning in achieving indigenous land justice and community goals. *Land Use Policy* 23(4):385–394
- Leung K, Bhagat RS, Buchan NR, Erez M, Gibson CB (2005) Culture and international business: recent advances and their implications for future research. *J Int Bus Stud* 36(4):357–378
- Lindsay NJ (2005) Toward a cultural model of indigenous entrepreneurial attitude. *Acad Mark Sci Rev* 5:1–15
- Llobera JR (2003) An invitation to anthropology: the structure, evolution and cultural identity of human societies. Berghahn Books, New York
- Löfgren B, Tillman A-M, Rinde B (2011) Manufacturing actor's LCA. *J Clean Prod* 19:2025–2033
- Luckman PG (2006) KiwiGrow(TM): a community and environmental health framework for sustainable development. In: Mander U, Brebbia CA, Tiezzi E (eds) *The sustainable city IV: urban regeneration and sustainability*. WIT Press, Ashurst, pp 155–168
- MacLean D (1996) Environmental ethics and human values. In: Cothorn RC (ed) *Handbook for environmental risk decision making: values, perceptions & ethics*. CRC, Boca Raton
- Macnaghten P, Jacobs M (1997) Public identification with sustainable development: investigating cultural barriers to participation. *Glob Environ Chang* 7(1):5–24
- Macombe C, Leskinen P, Feschet P, Antikainen R (2013) Social life cycle assessment of biodiesel production at three levels: a literature review and development needs. *J Clean Prod* 52:205–216
- Martín-López B, Gómez-Baggethun E, Lomas PL, Montes C (2009) Effects of spatial and temporal scales on cultural services valuation. *J Environ Manag* 90(2):1050–1059
- Mettier TM, Hofstetter P (2004) Survey insights into weighting environmental damages: influence of context and group. *J Ind Ecol* 8(4):189–209
- Miettinen P, Hämäläinen RP (1997) How to benefit from decision analysis in environmental life cycle assessment (LCA). *Eur J Op Res* 102(2):279–294
- Millennium Ecosystem Assessment (2005) *Ecosystems and human well-being: current state and trends*, vol 1. Island Press, Washington
- Molina-Murillo SA, Smith TM (2009) Exploring the use and impact of LCA-based information in corporate communications. *Int J Life Cycle Assess* 14:184–194
- Montes de Oca Munguia O, Harmsworth G, Young R, Dymond J (2009) The use of an agent-based model to represent Māori cultural values. 18th World IMACS/MODSIM Congress, Cairns, Australia, pp 2849–2855
- Moriizumi Y, Matsui N, Hondo H (2010) Simplified life cycle sustainability assessment of mangrove management: a case of plantation on wastelands in Thailand. *J Clean Prod* 18(16):1629–1638
- National Research Council (1994) *Building consensus: risk assessment and management in the Department of Energy's environmental remediation program*. Washington, DC
- Nissinen A, Grönroos J, Heiskanen E, Honkanen A, Katajajuuri J-M, Kurppa S, Mäkinen T, Mäenpää I, Seppälä J, Timonen P (2007) Developing benchmarks for consumer-oriented life cycle assessment-based environmental information on products, services and consumption patterns. *J Clean Prod* 15:538–549
- Noll H-H (2002) Towards a European system of social indicators: theoretical framework and system architecture. *Soc Indic Res* 58(1–3):47–87
- Nordic Council of Ministers (2010) *Arctic social indicators: follow-up to the Arctic Human Development report*. TemaNord, Copenhagen
- Nurse K (2006) Culture as the fourth pillar of sustainable development. In: *Small states: economic review and basic statistics*, vol 11. Commonwealth Secretariat, London, pp 28–40
- OECD (2011) *Society at a glance 2011—OECD social indicators*. www.oecd.org/els/social/indicators/SAG. Accessed 10 July 2013
- Palmer S (2011) Pilot of a tool for cultural impact assessment in local government RMA decisions: based on the Waiora concept of Māori wellbeing. Tumana Research, Coromandel, New Zealand
- Parent J, Cucuzzella C, Revéret J-P (2010) Impact assessment in SLCA: sorting the sLCIA methods according to their outcomes. *Int J Life Cycle Assess* 15:164–171
- Plieninger T, Dijks S, Oteros-Rozas E, Bieling C (2013) Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land Use Policy* 33:118–129
- RMA Quality Planning Resource (2012) *Consent support guidance note FAQ's about cultural impact assessments*. RMA Quality Planning Resource, Auckland, New Zealand
- Roccas S, Sagiv L (2010) Personal values and behavior: taking the cultural context into account. *Soc Personal Psychol Compass* 4(1):30–41
- Ross A, Pickering K (2002) The politics of reintegrating Australian Aboriginal and American Indian indigenous knowledge into resource management: the dynamics of resource appropriation and cultural revival. *Hum Ecol* 30(2):187–214
- Saastamoinen O (2005) Multiple ethics for multidimensional sustainability of forestry? *Silva Carelica* 49:37–53
- Saint-Arnaud M, Asselin H, Dube C, Croteau Y, Paptie C (2009) Developing criteria and indicators for Aboriginal forestry: mutual learning through collaborative research. In: Stevenson MG, Natcher DC (eds) *Changing the culture of forestry in Canada: building effective institutions for Aboriginal engagement in sustainable forest management*, vol 60. CCI Press Occasional Publication, Edmonton
- Sala S, Farioli F, Zamagni A (2013) Life cycle sustainability assessment in the context of sustainability science progress (part 2). *Int J Life Cycle Assess* 18(9):1686–1697
- Satterfield T, Gregory R, Klain S, Roberts M, Chan KM (2013) Culture, intangibles and metrics in environmental management. *J Environ Manag* 117:103–114
- Schaich H, Bieling C, Plieninger T (2010) Linking ecosystem services with cultural landscape research. *GAIA-Ecol Pers Sci Soc* 19(4):269–277
- Schmidt W-P, Sullivan J (2002) Weighting in life cycle assessments in a global context. *Int J Life Cycle Assess* 7(1):5–10
- Schwartz SH (1999) A theory of cultural values and some implications for work. *Appl Psychol* 48(1):23–47
- Schwartz SH (2006) A theory of cultural value orientations: explication and applications. *Comp Sociol* 5(2–3):137–182
- Scrimgeour F, Iremonger C (2004) *Māori sustainable economic development in New Zealand: indigenous practices for the quadruple bottom line*. University of Waikato, Hamilton, New Zealand
- Spiller R, Lake C (2003) Investing in culture—the 4th bottom line. *Ethical Invest* 22:14–15
- Stephenson J (2008) The cultural values model: an integrated approach to values in landscapes. *Landsc Urban Plann* 84(2):127–139
- Stephenson J, Moller H (2009) Cross-cultural environmental research and management: challenges and progress. *J R Soc N Z* 39(4):139–149
- Stevenson MG (1996) Indigenous knowledge in environmental assessment. *Arctic* 49(3):278–291
- Te Ao Marama Inc. (2004) *Cultural impact assessment on the Ngai Tahu spiritual and cultural relationship with the Manawapopore/Hikurangi (Mavora Lakes) area*
- Teddle C, Tashakkori A (2008) *Foundations of mixed methods research: integrating quantitative and qualitative approaches in the social and behavioral sciences*. Sage, Thousand Oaks
- Tengberg A, Fredholm S, Eliasson I, Knez I, Saltzman K, Wetterberg O (2012) Cultural ecosystem services provided by landscapes: assessment of heritage values and identity. *Ecosyst Serv* 2:14–26
- The Montréal Process (2009) *Criteria and indicators for the conservation and sustainable management of temperate and boreal forests*, 4th edn

- Thompson M, Ellis R, Wildavsky A (1990) Cultural theory. Political cultures series. Westview, Oxford
- Thrift N, Whatmore S (2004) Cultural geography: critical concepts in the social sciences. Routledge, London
- Tipa G, Teirney LD (2003) A Cultural Health Index for streams and waterways: indicators for recognising and expressing Māori values. Ministry for the Environment, Wellington, New Zealand
- Traverso M, Asdrubali F, Francia A, Finkbeiner M (2012) Towards life cycle sustainability assessment: an implementation to photovoltaic modules. *Int J Life Cycle Assess* 17(8):1068–1070
- Tukker A (2000) Life cycle assessment as a tool in environmental impact assessment. *Environ Impact Assess Rev* 20:435–456
- Tukker A (2002a) Life-cycle assessment and the precautionary principle. *Environ Sci Technol* 36(3):70A–75A
- Tukker A (2002b) Risk analysis, life cycle assessment—the common challenge of dealing with the precautionary frame (based on the toxicity controversy in Sweden and the Netherlands). *Risk Anal* 22(5):821–832
- Udo de Haes HA (2000) Weighting in life cycle assessment: is there a coherent perspective? *J Ind Ecol* 3(4):3–7
- UNEP, SETAC (2009) Guidelines for social life cycle assessment of products. United Nations Environment Programme (UNEP) and Society of Environmental Toxicology and Chemistry (SETAC), Belgium
- UNESCO (1972) Resolutions and recommendations 3.3: studies and development of culture, vol 1. Paris, France
- UNESCO (2001) UNESCO universal declaration on cultural diversity. Resolution 15 adopted by the General Conference at its 31st session, vol 1. Paris, France
- UNESCO (2003) Convention for the safeguarding of the intangible cultural heritage. Paris, France
- UNESCO (2005) Convention on the protection and promotion of the diversity of cultural expressions. Paris, France
- UNESCO (2009) Investing in cultural diversity and intercultural dialogue. Paris, France
- UNESCO (2010) Towards a UNESCO suite of indicators on culture and development: literature review
- United Nations (2007) United Nations Declaration on the Rights of Indigenous Peoples, vol G.A. Res. 61/295. United Nations, Geneva, Switzerland
- Valdivia S, Ugaya CML, Hildenbrand J, Traverso M, Mazijn B, Sonnemann G (2013) A UNEP/SETAC approach towards a life cycle sustainability assessment—our contribution to Rio+20. *Int J Life Cycle Assess* 18(9):1673–1685
- van den Bos K, Poortvliet PM, Maas M, Miedema J, van den Ham E-J (2005) An enquiry concerning the principles of cultural norms and values: the impact of uncertainty and mortality salience on reactions to violations and bolstering of cultural worldviews. *J Exp Soc Psych* 41:91–113
- Vancley F (2002) Conceptualising social impacts. *Environ Impact Assess Rev* 22(3):183–211
- Venn TJ, Quiggin J (2007) Accommodating indigenous cultural heritage values in resource assessment: Cape York Peninsula and the Murray–Darling Basin, Australia. *Ecol Econ* 61(2):334–344
- Vinyes E, Oliver-Solà J, Ugaya C, Rieradevall J, Gasol CM (2013) Application of LCSA to used cooking oil waste management. *Int J Life Cycle Assess* 18(2):445–455
- Walz R, Herrchen M, Keller D, Stahl B (1996) Impact category ecotoxicity and valuation procedure. *Int J Life Cycle Assess* 1(4):193–198
- Weidema BP, Lindeijer E (2001) Physical impacts of land use in product life cycle assessment. Final report of the EURENVIRON-LCAGAPS sub-project on land use. Lyngby, Denmark
- Weinstein JA (2005) Social and cultural change: social science for a dynamic world, 2nd edn. Rowman & Littlefield, Lanham
- Werner F (2005) Ambiguities in decision-oriented life cycle inventories: the role of mental models and values. Springer, Dordrecht
- Werner F, Scholz RW (2002) Ambiguities in decision-oriented life cycle inventories: the role of mental models. *Int J Life Cycle Assess* 7(6):330–338
- Wood R, Hertwich EG (2012) Economic modelling and indicators in life cycle sustainability assessment. *Int J Life Cycle Assess* 18(9):1710–1721
- World Commission on Culture and Development (1995) Our creative diversity: report of the World Commission on Culture and Development. UNESCO Publishing, Paris
- Zamagni A (2012) Life cycle sustainability assessment. *Int J Life Cycle Assess* 17:373–376
- Zamagni A, Buttol P, Buonamici R, Masoni P, Guinée JB, Huppes G, Heijungs R, van der Voet E, Ekvall T, Rydberg T (2009) D20 blue paper on life cycle sustainability analysis
- Zamagni A, Amerighi O, Buttol P (2011) Strengths or bias in social LCA? *Int J Life Cycle Assess* 16(7):596–598
- Zhou Z, Jiang H, Qin L (2007) Life cycle sustainability assessment of fuels. *Fuel* 86(1):256–263